

FORM PTO-1390 (Modified)  
(REV 11-2000)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

## TRANSMITTAL LETTER TO THE UNITED STATES

310.1027

DESIGNATED/ELECTED OFFICE (DO/EO/US)

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

CONCERNING A FILING UNDER 35 U.S.C. 371

10/069330

INTERNATIONAL APPLICATION NO.

INTERNATIONAL FILING DATE

PRIORITY DATE CLAIMED

PCT/NL00/00586

24 August 2000

24 August 1999

TITLE OF INVENTION

Method For Making A Dental Element

APPLICANT(S) FOR DO/EO/US

Feenstra, Frits Kornelis

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (24) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
  - a. ☒ is attached hereto (required only if not communicated by the International Bureau).
  - b. ☒ has been communicated by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
  - a. ☐ is attached hereto.
  - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
  - a. ☒ are attached hereto (required only if not communicated by the International Bureau).
  - b. ☒ have been communicated by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

## Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☒ Certificate of Mailing by Express Mail
23. ☒ Other items or information:

Acknowledgement postcard


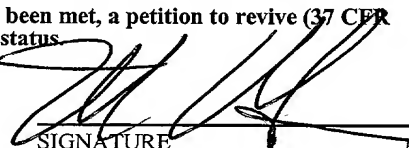
Unexecuted Declaration (3 pages)

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.101) <div style="font-size: 2em; font-weight: bold;">10/069330</div>	INTERNATIONAL APPLICATION NO. <div style="font-weight: bold;">PCT/NL00/00586</div>	ATTORNEY'S DOCKET NUMBER <div style="font-weight: bold;">310.1027</div>
--	---	--

24. The following fees are submitted: <b>BASIC NATIONAL FEE ( 37 CFR 1.492 (a) (1) - (5)) :</b> <input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... <b>\$1040.00</b> <input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... <b>\$890.00</b> <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... <b>\$740.00</b> <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... <b>\$710.00</b> <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) ..... <b>\$100.00</b> <div style="text-align: right;"><b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b></div>				CALCULATIONS PTO USE ONLY	
				<b>\$890.00</b>	
Surcharge of <b>\$130.00</b> for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)). <input type="checkbox"/> 20 <input checked="" type="checkbox"/> 30				<b>\$130.00</b>	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	12 - 20 =	0	x \$18.00	<b>\$0.00</b>	
Independent claims	1 - 3 =	0	x \$84.00	<b>\$0.00</b>	
Multiple Dependent Claims (check if applicable). <input type="checkbox"/>				<b>\$0.00</b>	
<b>TOTAL OF ABOVE CALCULATIONS =</b>				<b>\$1,020.00</b>	
<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				<b>\$0.00</b>	
<b>SUBTOTAL =</b>				<b>\$1,020.00</b>	
Processing fee of <b>\$130.00</b> for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)). <input type="checkbox"/> 20 <input type="checkbox"/> 30 +				<b>\$0.00</b>	
<b>TOTAL NATIONAL FEE =</b>				<b>\$1,020.00</b>	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). <input type="checkbox"/>				<b>\$0.00</b>	
<b>TOTAL FEES ENCLOSED =</b>				<b>\$1,020.00</b>	
				Amount to be: refunded	\$
				charged	\$

- a. ☐ A check in the amount of \_\_\_\_\_ to cover the above fees is enclosed.
- b. ☒ Please charge my Deposit Account No. 50-0217 in the amount of \$1,020.00 to cover the above fees. A duplicate copy of this sheet is enclosed.
- c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-0217 A duplicate copy of this sheet is enclosed.
- d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO: <b>Roberts &amp; Mercanti, L.L.P.</b> <b>EDC II</b> 105 Lock Street, Suite 203 Newark, New Jersey 07103 Phone: (973) 621-0660 Fax: (973) 621-0774		 <div style="font-size: 1.5em; font-weight: bold;">022856</div> <small>PATENT TRADEMARK OFFICE</small>	<div style="text-align: center;">             SIGNATURE         </div> <div style="text-align: center;"> <b>Michael N. Mercanti</b>            NAME         </div> <div style="text-align: center;"> <b>33,966</b>            REGISTRATION NUMBER         </div> <div style="text-align: center;"> <b>February 22, 2002</b>            DATE         </div>
---	--	---	--

10/069330  
JC19 Filed PCT/PTO 22 FEB 2002

**CERTIFICATE OF MAILING BY "EXPRESS MAIL" (37 CFR 1.10)**

Applicant(s): Feenstra, Frits K.

Docket No.

310.1027

Serial No. To be assigned	Filing Date Herewith	Examiner Unknown	Group Art Unit Unknown
------------------------------	-------------------------	---------------------	---------------------------

Invention: Method For Making A Dental Element

I hereby certify that the following correspondence:

PTO Form 1390 (2 pages, page 2 in duplicate)

*(Identify type of correspondence)*

is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 in an envelope addressed to: The Assistant Commissioner for Patents, Washington, D.C. 20231 on

February 22, 2002

*(Date)*

Michael N. Mercanti

*(Typed or Printed Name of Person Mailing Correspondence)*

  
*(Signature of Person Mailing Correspondence)*

EL 869, 002, 192 US

*("Express Mail" Mailing Label Number)*

Note: Each paper must have its own certificate of mailing.

**UNITED STATES PATENT & TRADEMARK OFFICE**

Examiner: Unknown Art Unit: Unknown  
Re: Application of: FEENSTRA, Frits Kornelis  
Serial No.: To be assigned  
Filed: herewith  
For: **METHOD FOR MAKING A DENTAL ELEMENT**

**PRELIMINARY AMENDMENT**

Assistant Commissioner  
for Patents  
Washington, D.C. 20231

February 22, 2002

Sir:

Prior to the examination, please amend the above-identified patent application as follows:

**IN THE CLAIMS:****Please amend claim 4 as follows:**

4. (Amended) A method according to claim 1, wherein measures are taken, such that each layer adheres at desired positions to a preceding layer, and excess, non-adhering material can be removed.

**Please amend claim 6 as follows:**

6. (Amended) A method according to claim 4, wherein the layers are applied using a piezo inkjet printer.

**Please amend claim 8 as follows:**

8. (Amended) A method according to claim 4, wherein a computer is used for controlling, on the basis of the data obtained upon measuring, a laser which cures the nanomeric material at specific, desired positions by irradiation.

**Please amend claim 9 as follows:**

9. (Amended) A method according to claim 4, wherein the dental element is exposed to a thermal post-treatment at a temperature of 60 to 150°C.

**Please amend claim 10 as follows:**

10. (Amended) A method according to claim 4, wherein the dental element is thermally densified at a temperature of at least 250°C.

**Please amend claim 11 as follows:**

11. (Amended) A method according to claim 1, wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed.

**Please amend claim 12 as follows:**

12. (Amended) A dental element obtainable by a method according to claim 1.

**REMARKS**

This amendment is being submitted to remove all multiple dependent claims which were presented during the international phase of the PCT for this application. Attached hereto is a marked-up version of the changes made to the claims by the preliminary amendment. The attached appendix is captioned "**Version with markings to show changes made.**"

The Examiner is alerted to the fact that the claims amended herein are the same as those submitted by Applicant during the international phase of the PCT on November 5, 2001 and examined by the International Preliminary Examining Authority as part of preparing the International Preliminary Examination Report.

It is respectfully submitted that no new matter has been entered and that the present application is in all respects complete and in condition for favorable consideration.

If the Examiner has any questions regarding the amendment presented herein, it is requested that the Examiner contact the undersigned at the telephone number shown below.

An early and favorable action on the merits is earnestly solicited.

Respectfully submitted,

ROBERTS & MERCANTI, L.L.P.



Michael N. Mercanti

Reg. No. 33,966

ROBERTS & MERCANTI, L.L.P.

105 Lock Street, Suite 203

Newark, New Jersey 07103

Phone: 973-621-0660

Fax: 973-621-0774

"Express Mail" mailing label no EL 869 002 192 US

Date of Deposit February 22, 2002

I hereby certify that this correspondence and/or fee is being deposited with the United States Postal Service

"Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above, in an envelope addressed to: "Assistant Commissioner for Patents, Washington, DC 20231".

ROBERTS & MERCANTI, L.L.P.

By: 

Michael N. Mercanti

310.1027

**UNITED STATES PATENT & TRADEMARK OFFICE**

Examiner: Unknown Art Unit: Unknown  
Re: Application of: FEENSTRA, Frits Kornelis  
Serial No.: To be assigned  
Filed: herewith  
For: **METHOD FOR MAKING A DENTAL ELEMENT**

**APPENDIX I**  
**VERSION WITH MARKINGS TO SHOW CHANGES MADE**

**IN THE CLAIMS:**

**Claim 4 has been amended as follows:**

4. (Amended) A method according to [any one of the preceding claims] claim 1, wherein measures are taken, such that each layer adheres at desired positions to a preceding layer, and excess, non-adhering material can be removed.

**Claim 6 has been amended as follows:**

6. (Amended) A method according to claim 4 [or 5], wherein the layers are applied using a piezo inkjet printer.

**Claim 8 has been amended as follows:**

8. (Amended) A method according to [claims 4-7] claim 4, wherein a computer is used for controlling, on the basis of the data obtained upon measuring, a laser which cures the nanomeric material at specific, desired positions by irradiation.

**Claim 9 has been amended as follows:**

9. (Amended) A method according to [claims 4-8] claim 4, wherein the dental element is exposed to a thermal post-treatment at a temperature of 60 to 150°C.

**Claim 10 has been amended as follows:**

10. (Amended) A method according to [claims 4-9] claim 4, wherein the dental element is thermally densified at a temperature of at least 250°C.

**Claim 11 has been amended as follows:**

11. (Amended) A method according to [any one of the preceding claims] claim 1, wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed.

**Claim 12 has been amended as follows:**

12. (Amended) A dental element obtainable by a method according to [any one of the preceding claims] claim 1.

"Express Mail" mailing label no EL 869 002 192 US

Date of Deposit February 22, 2002

I hereby certify that this correspondence and/or fee

is being deposited with the United States Postal Service

"Express Mail Post Office to Addressee" service under 37

CFR 1.10 on the date indicated above, in an envelope

addressed to: "Assistant Commissioner for Patents,

Washington, DC 20231".

ROBERTS & MERCANTI L.L.P.

By:

Michael N. Mercanti

K:\wpdocs\PATENT\310 Vereenigde\1027\appendix version.wpd



WO 01/13815

PCT/NL00/00586

Title: Method for making a dental element.

The invention relates to a method for making a functional dental element and to a dental element obtainable by such method.

Dental elements, such as crowns, are used in clinical practice mainly for replacing or correcting dental structures. This can involve partly  
5 or wholly lost teeth or molars. To date, materials for such elements have been examined in particular for technological/physical and chemical properties. Currently, in addition, the biological aspect plays an increasing role.

Dental elements can be fabricated from different materials.  
10 Examples include polymers, metals, composites, combinations of porcelain and metal, porcelain and other ceramic materials. Glass and ceramic materials form an ideal group of materials for dental elements, because they are hard, have a high wear resistance, are chemically inert in many media (biocompatibility), and can be simply formed into an aesthetic dental  
15 element. A broad application of these materials, however, is impeded by the inherent brittleness which is often the result of limitations in the fabricating process and of the material choice. Recent developments have led to different ceramic systems, such as sintered ceramic, glass-infiltrated ceramic and glass-ceramic of various compositions, which are less brittle.

20 The fabrication of dental elements in practice is a complex and time consuming affair. The products involved are fabricated on an individual basis since the exact form of the element is different for every tooth or molar in every individual. Conventional techniques that have been used often utilize a mold. Since this mold can typically be used only once, it  
25 will be clear that these techniques are very costly.

In the past, techniques have been proposed which supposedly enable simplification of the fabricating process of dental elements. Thus,

10069330-051402

WO 01/13815

2

PCT/NL00/00586

10069330-051402

Abe et al., in Int. J. Japan Soc. Prec. Eng., vol. 30, no. 3, 1996, pp. 278-279, have proposed to carry out a selective laser sintering (SLS) with titanium. This technique, however, often gives rise to shrinkage. Also, microcracks may be formed, which renders the technique unsuitable for the fabrication of functional dental elements. In European patent application 0 311 214 it has been proposed to make a crown by milling. Milling does not provide the possibility of making colored elements. Moreover, the choice of suitable materials that can be processed by milling is limited. As noted, ceramic materials form an ideal group of materials for fabricating dental elements, because they are hard, highly wear-resistant and inert under many conditions.

U.S. Patent 5,690,490 describes a method for the fabrication of a concept model for a dental element by so-called pinhead molding. The method concerns the use of a kind of matrix printing technique, whereby material is sprayed on. The printer is controlled with a CAD/CAM program. The data which this program utilizes have been obtained from a laser scan of the tooth or the molar to be replaced.

In U.S. Patent 5,823,778, a method is described for fabricating a dental element whereby an impression of the teeth of a patient is obtained, which is subsequently used as a mold to make a copy of a dental element. This element is broken down in layers and each layer is scanned to obtain a three-dimensional computer model of the dental element.

One object of the present invention is to provide a technique whereby functional dental elements can be fabricated in a flexible and efficient manner. Another object is for the technique not to utilize a mold, and to enable making dental elements of polymeric, metallic or ceramic material, or of combinations thereof.

Surprisingly, it has presently been found that the stated objects are achieved by fabricating a dental element utilizing a three-dimensional printing technique.

WO 01/13815

PCT/NL00/00586

3

Three-dimensional printing techniques are known per se, and described inter alia in European patent application 0 431 924, U.S. Patent 5,902,441 and international patent applications 94/19112, 97/26802 and 98/51747. For a description of the details of the technique, reference is made to the documents mentioned, which are therefore to be understood to be inserted herein.

The method according to the invention is in principle suitable for fabricating all types of dental elements. Examples include crowns (front and lateral teeth), inlays, overlays, onlays, partial crowns, fixations and veneers.

Preferably, in a patient in whom a dental element is to be replaced/placed, it is first accurately measured what shape the element is to have. Often, if possible, the starting point will be the shape of the tooth or molar, or the portion thereof that is to be replaced. It is preferred that measurement can take place in a manner which causes the patient as little inconvenience as possible. Particularly suitable techniques for measuring the shape for the dental element make use of optical scan techniques, in particular lasers. In electronic form, data about the desired shape and dimensions are thereby obtained, which can be directly visualized in a computer. The electronic data about the shape and dimensions of the dental element are preferably used by a computer to control the execution of the three-dimensional printing technique. Another suitable method for measuring is by the CEREC-technique, Sirona Dental Systems GmbH, Bensheim, Germany.

In the three-dimensional printing technique, a suitable material is applied successively in layers, while specific steps are taken to ensure that each layer adheres to the preceding layer only at particular desired points. These specific steps are determined by the desired shape of the dental element and preferably controlled by the above-mentioned electronic data.

According to the invention, in the specific steps mentioned, use is made of a selective curing. The dental element is built up from layers, this

10069330-051402

WO 01/13815

PCT/NL00/00586

4

time of a specific curable material, whereby each layer adheres to the desired positions of the preceding layer by allowing the material to cure only at the desired positions. The non-cured material will not adhere to the preceding layer and can be readily removed.

5 The curable material is preferably a nanomeric material, as described in WO-A-98/51747. Such a material consists of nanomeric, inorganic solid particles having polymerizable and/or polycondensable organic groups at their surface. It is preferred that this material is applied in the form of a flowable mass, for instance a dispersion of the material in  
10 water, an organic solvent, or a monomeric solution. In this context, a monomer solution is understood to mean a mixture of UV photopolymerizable monomers and a solvent suitable therefor. Suitable examples of monomers contain epoxy and/or acryl groups. As solvent, for instance styrene can be used. Nanomeric inorganic solid particles are  
15 understood to be particles having an average particle size (diameter) of less than 200 nm, preferably less than 100 nm. Found to be particularly suitable are particles having an average diameter of 5-50 nm.

The nanomeric, inorganic solid particles can consist of different materials, but it is preferred that they comprise a metal or metal compound.  
20 Examples of suitable materials are inter alia ZnO, CdO, SiO<sub>2</sub>, TiO<sub>2</sub>, ZrO<sub>2</sub>, CeO<sub>2</sub>, SnO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, In<sub>2</sub>O<sub>3</sub>, La<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, Cu<sub>2</sub>O, Ta<sub>2</sub>O<sub>5</sub>, Nb<sub>2</sub>O<sub>5</sub>, V<sub>2</sub>O<sub>5</sub>, MoO<sub>3</sub>, WO<sub>3</sub>, CdS, ZnS, PbS, Ag<sub>2</sub>S, GaSe, CdSe, ZnSe, ZnTe, CdTe, AgCl, AgBr, AgI, CuCl, CuBr, CdI<sub>2</sub>, PbI<sub>2</sub>, CdC<sub>2</sub>, SiC, AlAs, GaAs, GeAs, InSb, BN, AlN, Si<sub>3</sub>N<sub>4</sub>, Ti<sub>3</sub>N<sub>4</sub>, GaP, InP, Zn<sub>3</sub>P<sub>2</sub>, Cd<sub>3</sub>P<sub>2</sub>, phosphates, silicates, zirconates,  
25 aluminates, stannates and corresponding mixed oxides (as with a perovskite structure, e.g. BaTiO<sub>3</sub> and PbTiO<sub>3</sub>). Preferred are materials comprising oxides, sulfides, selenides or tellurides of metals, or mixtures thereof. Preferred in particular are nanomeric particles of SiO<sub>2</sub>, TiO<sub>2</sub>, ZrO<sub>2</sub>, ZnO, Ta<sub>2</sub>O<sub>5</sub>, SnO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> (in all forms, in particular as boehmite, AlO(OH))  
30 and mixtures thereof.

204T50"051402

**WO 01/13815**

**PCT/NL00/00586**

5

The polymerizable and/or polycondensable organic groups can preferably form polymers under the influence of irradiation with a laser. This polymerization can proceed via any suitable mechanism. Preferably, the polymerization is photochemical or thermal. If desired, an initiator can be added to the flowable mass, being the form in which the nanomeric material is processed. (Meth)acryl, allyl, vinyl, epoxy, hydroxy, carboxy and amino groups are preferred, a particular preference being expressed for (meth)acryl and epoxy groups.

According to the invention, it is preferred that the polymerizable  
10 and/or polycondensable organic groups have a relatively low molecular  
weight. Preferably, their molecular weight is below 500, more preferably  
below 200.

The preparation of nanomeric, inorganic solid particles with polymerizable and/or polycondensable organic groups at their surface is known per se and described, inter alia, in international patent application 98/51747.

As mentioned, the nanomeric material is applied in the form of a flowable mass in layers. The flowable mass can be formed by forming a dispersion of the nanomeric material in water or any other suitable solvent. Here, it is preferred to work with a concentration between 25 and 60% by weight of nanomeric material, based on the weight of the dispersion. Applying the layers can be done in any suitable manner, such as spraying, streaking and the like. The thickness of the layers in these cases is preferably between 0.01 and 0.1 mm.

25           Between the application of the successive different layers, each layer is cured at specific, desired positions. The electronic data which have been obtained by measuring the shape and dimensions of the desired dental element in a patient can be used to control a laser which accurately irradiates each layer at the desired positions, so that the desired curing

WO 01/13815

PCT/NL00/00586

6

occurs and the layer adheres to a preceding layer at the desired points.

Material which has not cured can be easily removed.

This method can also, as a special feature, process UV curing nanomer-containing resins which have been colored (with inorganic colorant), which enables the fabrication of colored functional dental elements. This process also provides the possibility of illuminating, and thereby curing, the surface in one go using a UV lamp, which proceeds faster than local curing with a laser. The process utilizes a number of nozzles equal to a power of 2, preferably between 100 and 10,000 nozzles, in particular 1536 nozzles. According to an alternative embodiment, the flowable mass can be applied in layers using an inkjet method. Preferably, use is made here of a piezo inkjet printer with a head of preferably 1536 nozzles. In this case, the thickness of the layers is preferably between 10 and 40  $\mu\text{m}$ .

In particular cases, it has been found to be advantageous to subject the dental element to a thermal post-treatment, so that a complete curing is achieved. Thus, preferably, the dental element is briefly heated to a temperature between 60 and 150°C, more preferably between 80 and 130°C.

Instead thereof, or supplemental thereto, preferably a thermal densification is accomplished. To that end, the dental element is heated to a temperature of at least 250°C, preferably at least 400°C and more preferably at least 500°C. This treatment contributes to the dental element obtaining particularly favorable properties.

When by one of the procedures described above the dental element has been formed, it may happen that it still needs to be additionally shaped to some extent. As has already been indicated, it is an advantage of the invention that it enables work to be done very accurately. Additional shaping will therefore be less laborious than in the techniques used heretofore. Ways in which additional shaping can be carried out include inter alia grinding, filing, polishing, sanding, blasting or treatment with a

WO 01/13815

PCT/NL00/00586

7

ball bed, depending on the selected material of the dental element. After this, typically a surface treatment/sealing is desirable.

The invention will presently be elucidated in and by the following examples.

5

### Example 1

ZrO<sub>2</sub> particles of an average diameter of 10 nm are dispersed in isopropanol with stirring and ultrasound treatment. To modify the surface of the particles, 3.2 wt.%, based on the ZrO<sub>2</sub> content, of  
10 3-methacryloxypropyltrimethoxysilane (MPTS) is added. The dispersion is stirred at 50°C for 3 hours to obtain a silanized surface.

Subsequently, 3.2 wt.%, based on the ZrO<sub>2</sub> content, of tetraethyleneglycoldimethacrylate (TEGDMA) is added and stirring is done at 20°C for 15 minutes. Three mole % of Irgacure® 184 is added per mole of  
15 double bond. Then the solvent is partly removed under vacuum.

Of the material thus obtained, the curing depth (Cd) is determined. An amount of the material is brought into a cylindrical form, which form transmits UV radiation. A UV dryer having a power of 400 mW/cm<sup>2</sup> is used for curing. The material is exposed to radiation for a period between 1 and 2  
20 minutes (up to 20 UV radiation cycles). The power used is varied. The results of this tunnel curing test are programmed into an SLA machine (SLA250 of the firm 3D Systems Inc., Valencia CA USA).

Of the above-described dispersion, a layer of a thickness of 0.05 mm is applied to a building surface (20x20 cm) using a doctor blade. This layer is  
25 selectively irradiated with a HeCd laser, so that at specific points a curing reaction is initiated. This procedure is repeated until an element of the desired shape and dimension has been obtained. Finally, the element is exposed to a heat treatment at 120°C for 15 minutes.

10069330-051402

KROON/P49296PC10

Printed: 19-11-2003 appln. no. PCT/NL00/00586 CEMSPAMD

Our letter of 5 November 2001

EPC-D 02957136-NL-0000

05.11.2001

(99)

## Amended Claims

1. A method for fabricating a functional dental element by a three-dimensional printing technique, wherein successive layers of a flowable mass comprising a nanomeric material are applied onto each other using an inkjet method, and wherein the bonding between the layers is realized by curing the nanomeric material.
- 5 2. A method according to claim 1, wherein the shape and dimensions of the dental element are measured in a patient while using an optical scan technique, preferably a laser technique.
3. A method according to claim 2, wherein the laser technique yields data about shape and dimensions in electronic form.
- 10 4. A method according to any one of the preceding claims, wherein measures are taken, such that each layer adheres at desired positions to a preceding layer, and excess, non-adhering material can be removed.
5. A method according to claim 4, wherein the nanomeric material consists of nanomeric, inorganic solid particles with polymerizable and/or polycondensable  
15 organic groups at their surface.
6. A method according to claim 4 or 5, wherein the layers are applied using a piezo inkjet printer.
7. A method according to claim 6, wherein curing is done using UV light.
8. A method according to claims 4-7, wherein a computer is used for controlling,  
20 on the basis of the data obtained upon measuring, a laser which cures the nanomeric material at specific, desired positions by irradiation.
9. A method according to claims 4-8, wherein the dental element is exposed to a thermal post-treatment at a temperature of 60 to 150°C.
10. A method according to claims 4-9, wherein the dental element is thermally  
25 densified at a temperature of at least 250°C.
11. A method according to any one of the preceding claims, wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed.
12. A dental element obtainable by a method according to any one of the preceding  
30 claims.



## (12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

(43) International Publication Date  
1 March 2001 (01.03.2001)

PCT

(10) International Publication Number  
**WO 01/13815 A1**

- (51) International Patent Classification: A61C 13/00, B29C 67/80, A61K 6/083
- (74) Agent: PRINS, A., W.; Vereenigde, Nieuwe Parklaan 97, NL-2587 BN The Hague (NL).
- (21) International Application Number: PCT/NL00/00586
- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (22) International Filing Date: 24 August 2000 (24.08.2000)
- (25) Filing Language: Dutch
- (26) Publication Language: English
- (30) Priority Data:  
1012897 24 August 1999 (24.08.1999) NL
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
- (71) Applicant (*for all designated States except US*): NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUURWETENSCHAPPELIJK ONDERZOEK TNO [NL/NL]; Schoemakerstraat 97, NL-2628 VK Delft (NL).
- Published:  
— With international search report.
- (72) Inventor; and
- (75) Inventor/Applicant (*for US only*): FEENSTRA, Frits, Kornelis [NL/NL]; Rosa Manuslaan 48, NL-2642 DR Pijnacker (NL).
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: METHOD FOR MAKING A DENTAL ELEMENT

(57) Abstract: The present invention relates to a method for fabricating a functional dental element, such as a crown. According to the invention, use is made of a three-dimensional printing technique. The major advantages of the invention are that no mold is needed anymore, which entails a considerable saving of costs, that a great accuracy is achieved, and that the element can be made of different materials.

WO 01/13815 A1

Rec'd PCT/PTO 14 MAY 2002

Please type a plus sign (+) inside this box → ☐

PTO/SB/01 (10-00)

Approved for use through 10/31/2002. OMB 0651-0032  
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION</b> <b>(37 CFR 1.63)</b>  <input type="checkbox"/> Declaration Submitted with Initial Filing    OR <input checked="" type="checkbox"/> Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)))	<b>Attorney Docket Number</b>	310.1027
	<b>First Named Inventor</b>	Feenstra, Frits Kornelis
	<b>COMPLETE IF KNOWN</b>	
	<b>Application Number</b>	10 / 069,330
	<b>Filing Date</b>	02/22/2002
	<b>Group Art Unit</b>	
	<b>Examiner Name</b>	

As a below named inventor, I hereby declare that:

My residence, mailing address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Method For Making A Dental Element

the specification of which

(Title of the Invention)

☐ is attached hereto

OR

☒ was filed on (MM/DD/YYYY)

02/22/2002

as United States Application Number or PCT International

Application Number

10/069,330

and was amended on (MM/DD/YYYY)

02/22/2002

(if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above:

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application		Foreign Filing Date	Priority	Certified Copy Attached?	
				YES	NO
PCT/NL00/00586 NL1012897	PCT Netherlands	24 August2000 24 August1999	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.


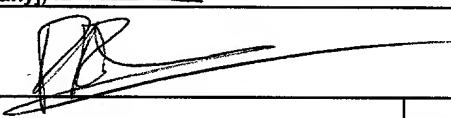
Application Number(s)	Filing Date (MM/DD/YYYY)	
		<input type="checkbox"/> Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

[Page 1 of 2]

Burden Hour Statement: This form is estimated to take 21 minutes to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

204750 "0669007"

**DECLARATION — Utility or Design Patent Application**

Direct all correspondence to:		<input checked="" type="checkbox"/> Customer Number or Bar Code Label		OR <input type="checkbox"/> Correspondence address below
<b>022856</b>				
Name				
PATENT TRADEMARK OFFICE				
Address				
Address				
City		State	ZIP	
Country	Telephone		Fax	
<p>I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.</p>				
NAME OF SOLE OR FIRST INVENTOR :		<input type="checkbox"/> A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])		Family Name or Surname		
<u>Frits Kornelis</u>		<u>Feenstra</u>		
Inventor's Signature				Date <u>12 March 2002</u>
Residence: City	<u>Pijnacker</u>	State <u>NL</u>	Country <u>NL</u>	Citizenship <u>DUTCH</u>
Mailing Address <u>Rosa Manuslaan 48</u>				
Mailing Address <u>2642 DR</u>				
City	<u>Pijnacker</u>	State	ZIP	Country <u>The Netherlands</u>
NAME OF SECOND INVENTOR:		<input type="checkbox"/> A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])		Family Name or Surname		
Inventor's Signature				Date
Residence: City		State	Country	Citizenship
Mailing Address				
Mailing Address				
City		State	ZIP	Country
<input type="checkbox"/> Additional inventors are being named on _____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.				